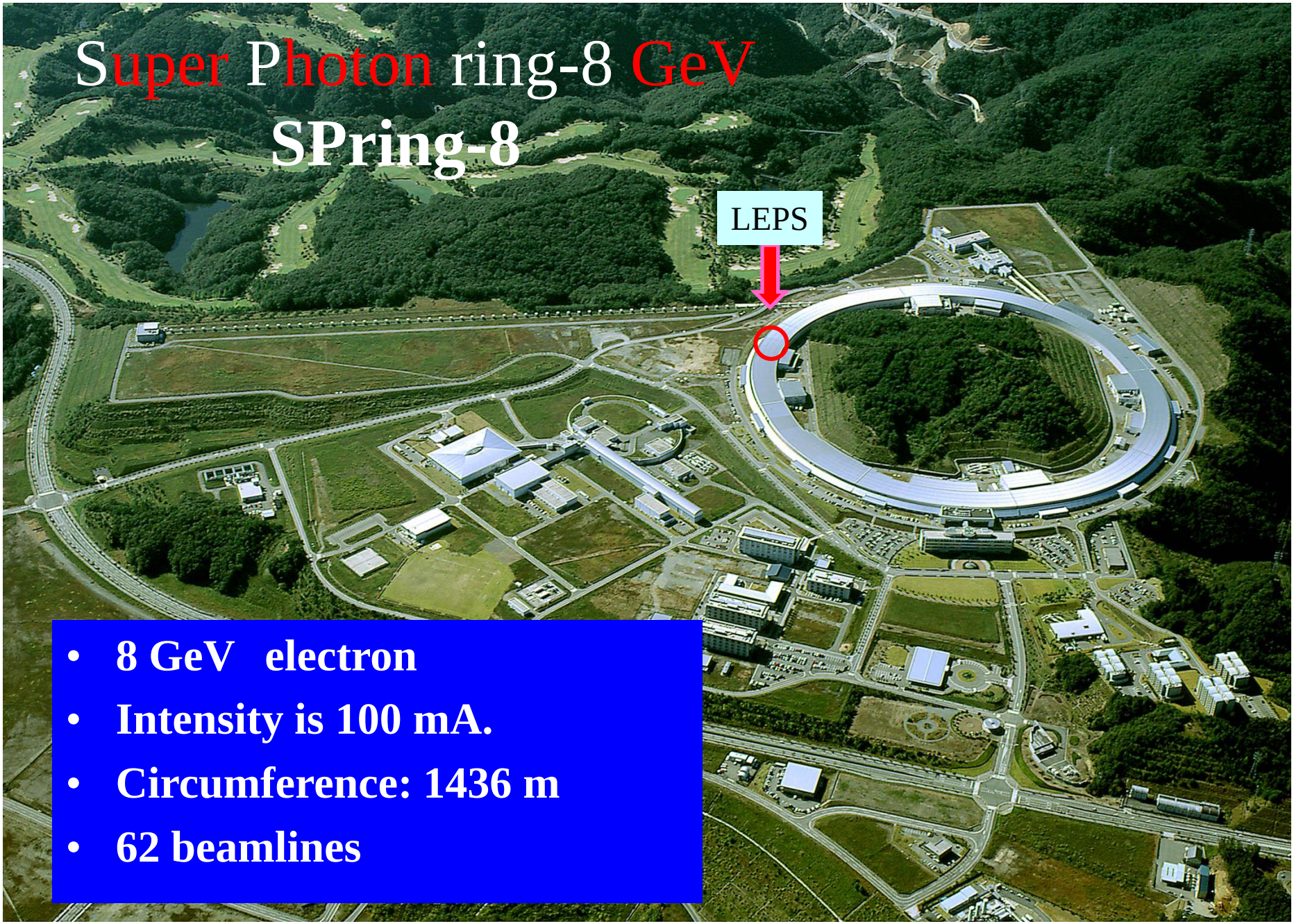
Status of LEPS

Mizuki Sumihama
For LEPS collaboration
Gifu university

- Introduction of LEPS
- Previous work
- Update (new setup)
- Status of present work

New hadron 2011.3.1


Super Photon ring-8 GeV
SPring-8
LEPS
• 8 GeV electron
• Intensity is 100 mA.
• Circumference: 1436 m
• 62 beamlines

Laser Electron Photon beam

8 GeV electron

Collision

Recoil electron

Backward-Compton scattering

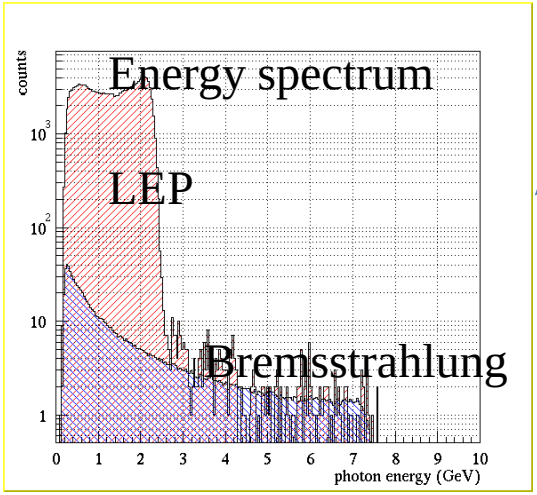
Tagging counter

36m

a) SPring-8
SR ring

Laser light

70m



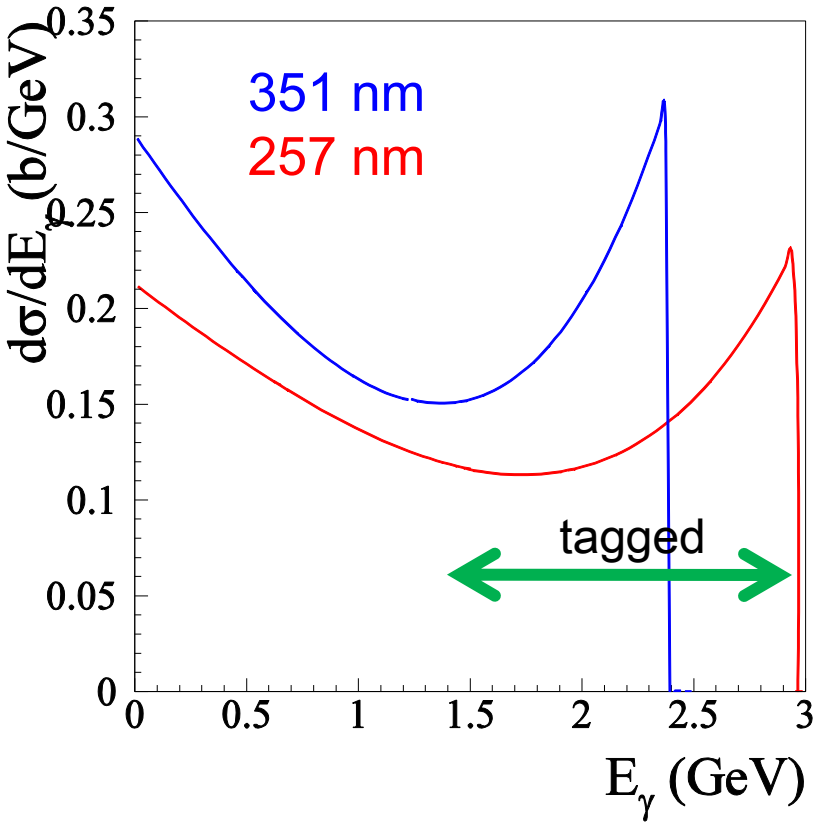
b) Laser hutch

Inverse Compton γ-ray

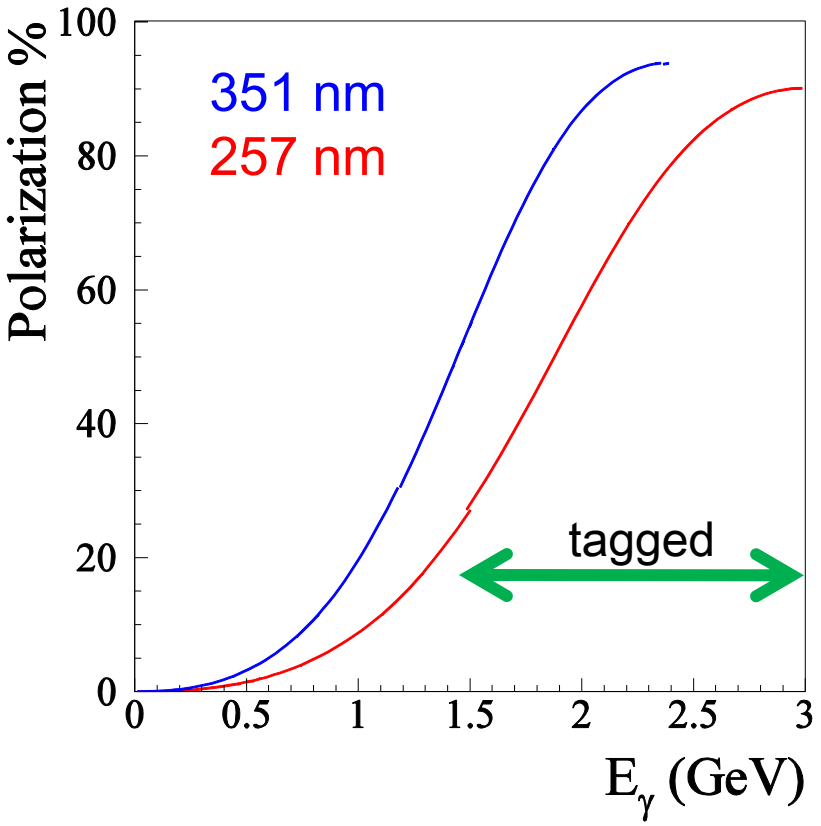
c) Experimental hutch

Linearly polarized photons

Cross section(Energy spectrum)



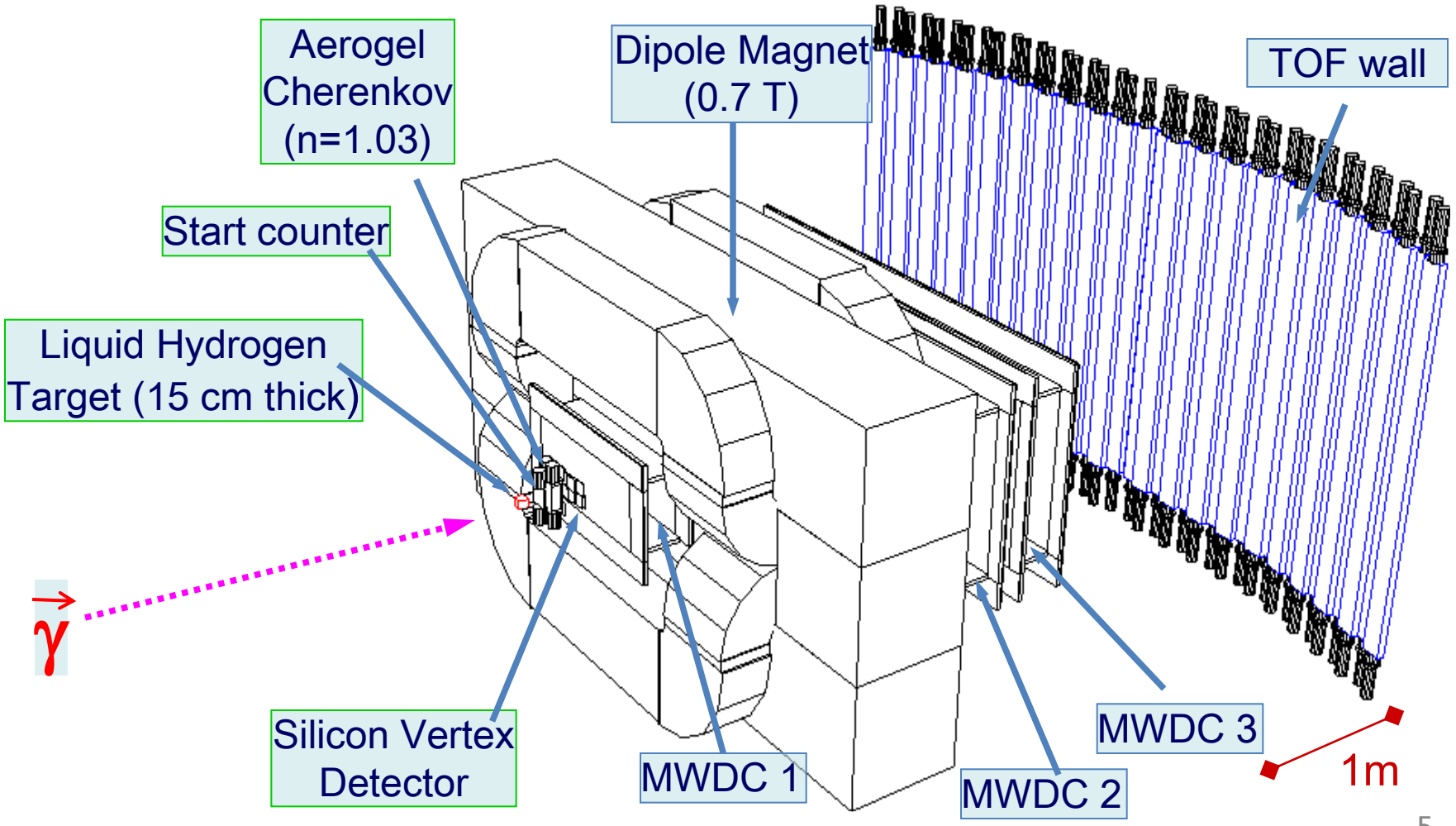
Linear Polarization



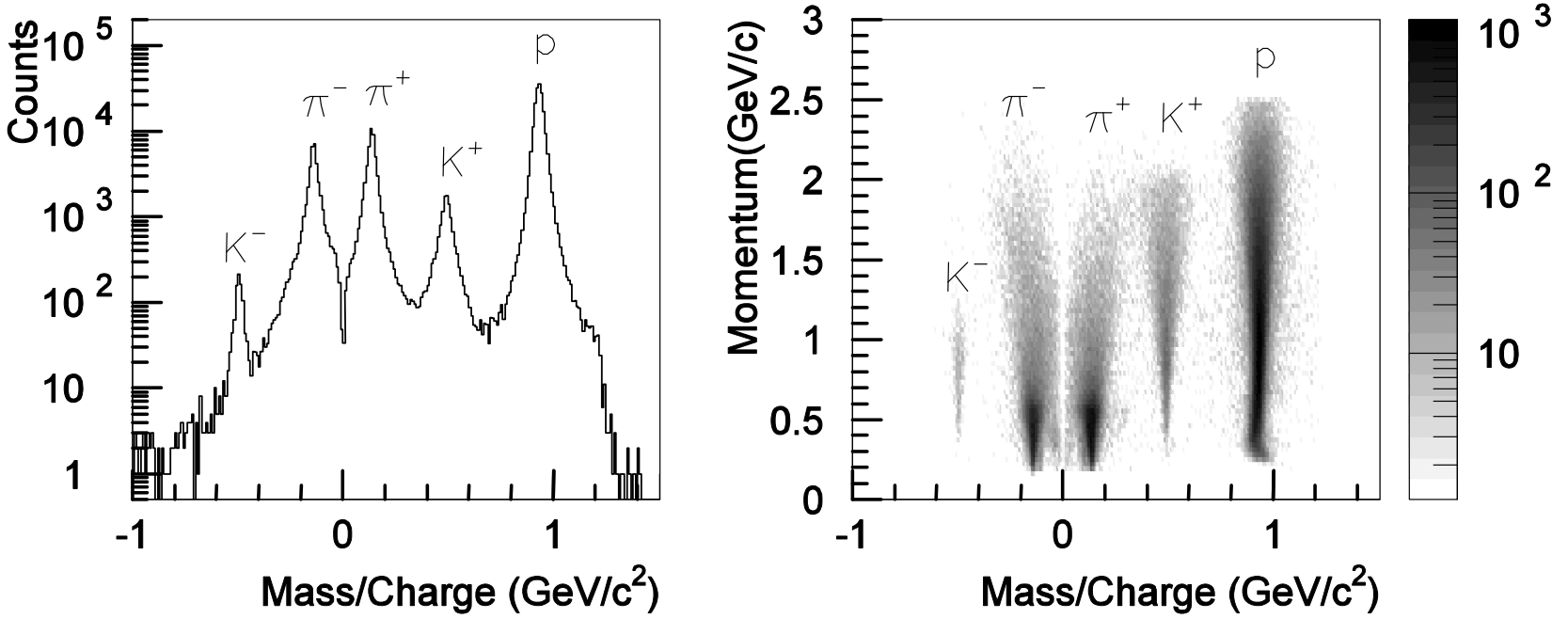
Polarization of photon beam is calculated by using photon energy event by event.

LEPS spectrometer – forward acceptance

± 10° in y
± 20° in x



Particle identification



Time resolution ~120ps

Momentum resolution ~5(14) MeV for 1(2) GeV/c Kaon

Previous works at LEPS

http://www.rcnp.osaka-u.ac.jp/~sp8lep

✓Linearly polarized photon beam

E_γ = 1.5 – 2.4 GeV / $W_{\text{p target}}$ = 1.9 – 2.3 GeV

✓Target

Liquid hydrogen / deuteron / Li, Al, Cu, C

✓Channels

hyperon : $\gamma p \rightarrow K^+\Lambda$, $K^+\Sigma^0$, $K^+\Lambda(1520)$, $K^+\Lambda(1405)$, $K^+\Sigma(1385)$

$\gamma n \rightarrow K^+\Sigma^-$, $K^+\Sigma^{*-}$

Time projection chamber

ϕ, π^0, η meson : $\gamma p \rightarrow \phi p$, $\gamma d \rightarrow \phi d$, $\gamma N \rightarrow \phi N$, $\gamma A \rightarrow \phi A$

$\gamma p \rightarrow \eta p$, $\gamma p \rightarrow \pi^0 p$,

Θ^+ (petaquark) : $\gamma n(C) \rightarrow$, $\gamma n(d) \rightarrow K^-\Theta^+$

- Missing baryon resonances (N*, Δ*), ~2000MeV
- Exotic hadron, Θ^+, $\Lambda(1405)$

Advantage of photon beam

$\gamma + N \rightarrow *$

- πN, ρN, ηN, $\eta' N$, ωN, ϕN, KY, KY* …, simultaneously
- Polarization observables –linearly polarized photon,
  parity filter
  polarized target under construction
- Isospin filter :
  η, η', ω / Λ I=0, → N* only
  π, ρ / Σ I=1, → N* and Δ*
- Strangeness channel (ss-bar)
  $K\Lambda$, $K\Sigma$, $K\Lambda$*, $K\Sigma$*, ϕN, ηN, $K^{-}\Theta^{+}$

Multi-channel analysis

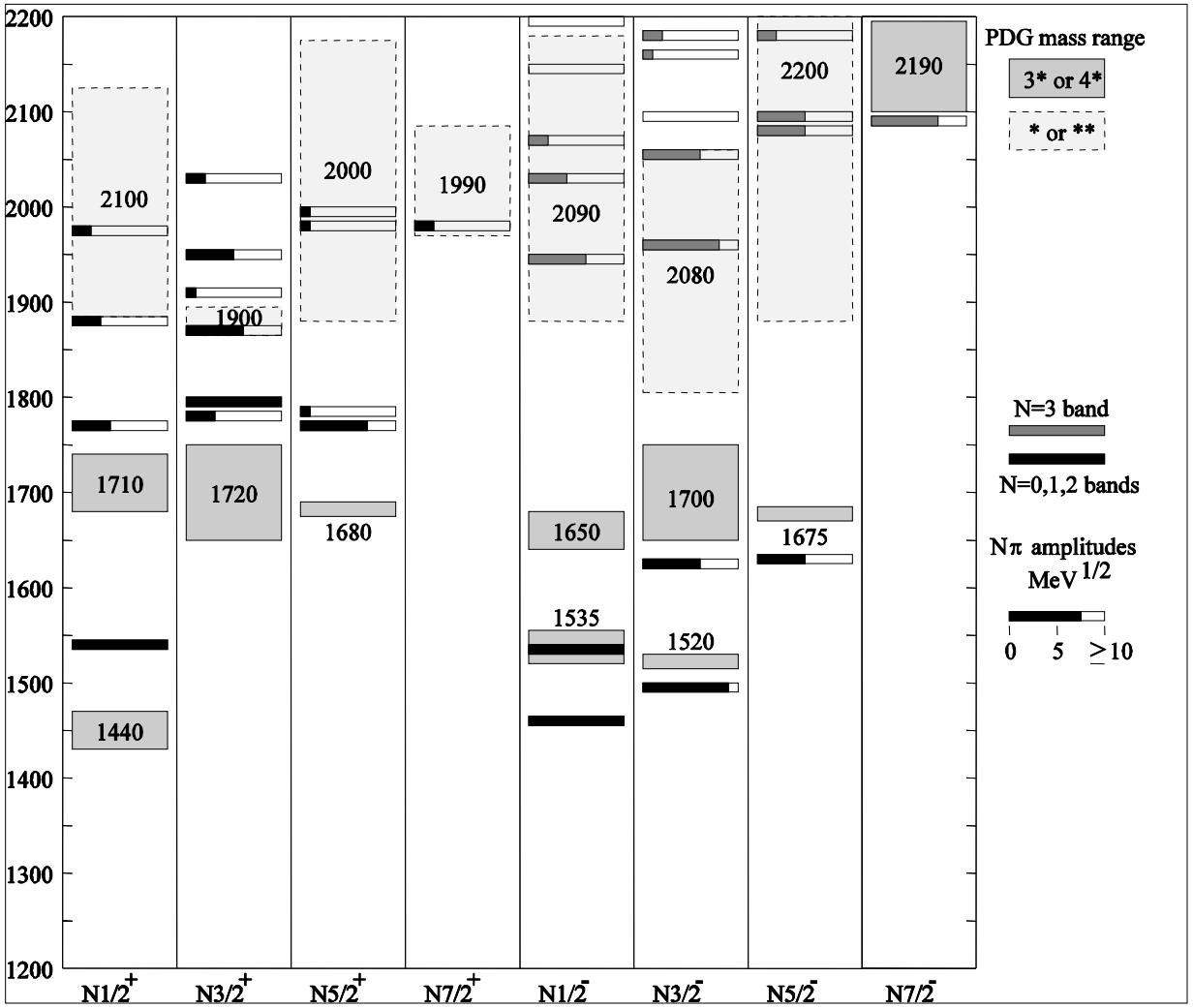
Table of baryon excited states –PDG assessment

LEPS range

Many *, or ** states

1700 MeV

, or * states



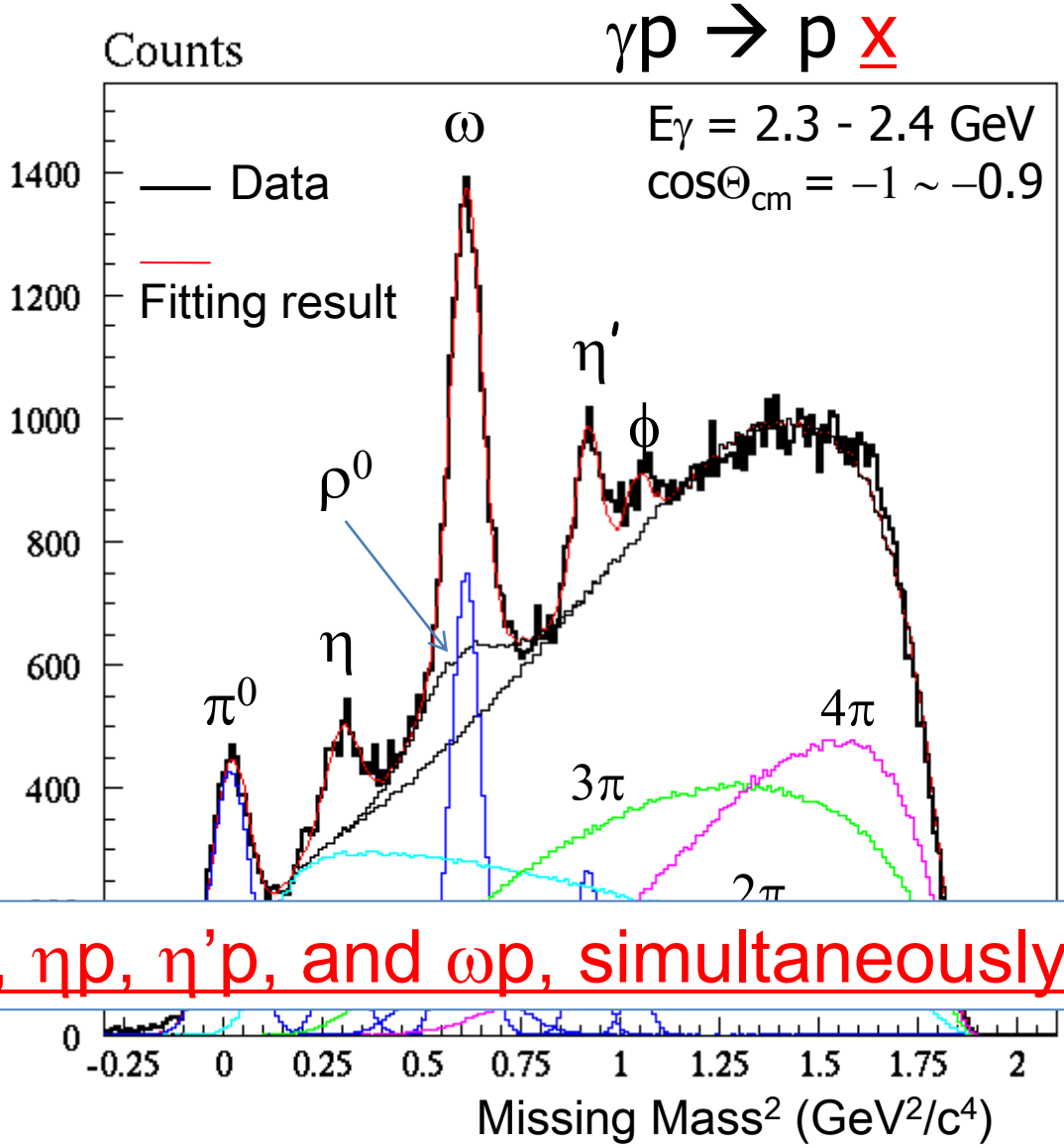
Backward meson photoproduction

Background

$\gamma p \rightarrow p \pi \pi$

$\gamma p \rightarrow p \pi \pi \pi$

$\gamma p \rightarrow p \pi \pi \pi \pi$



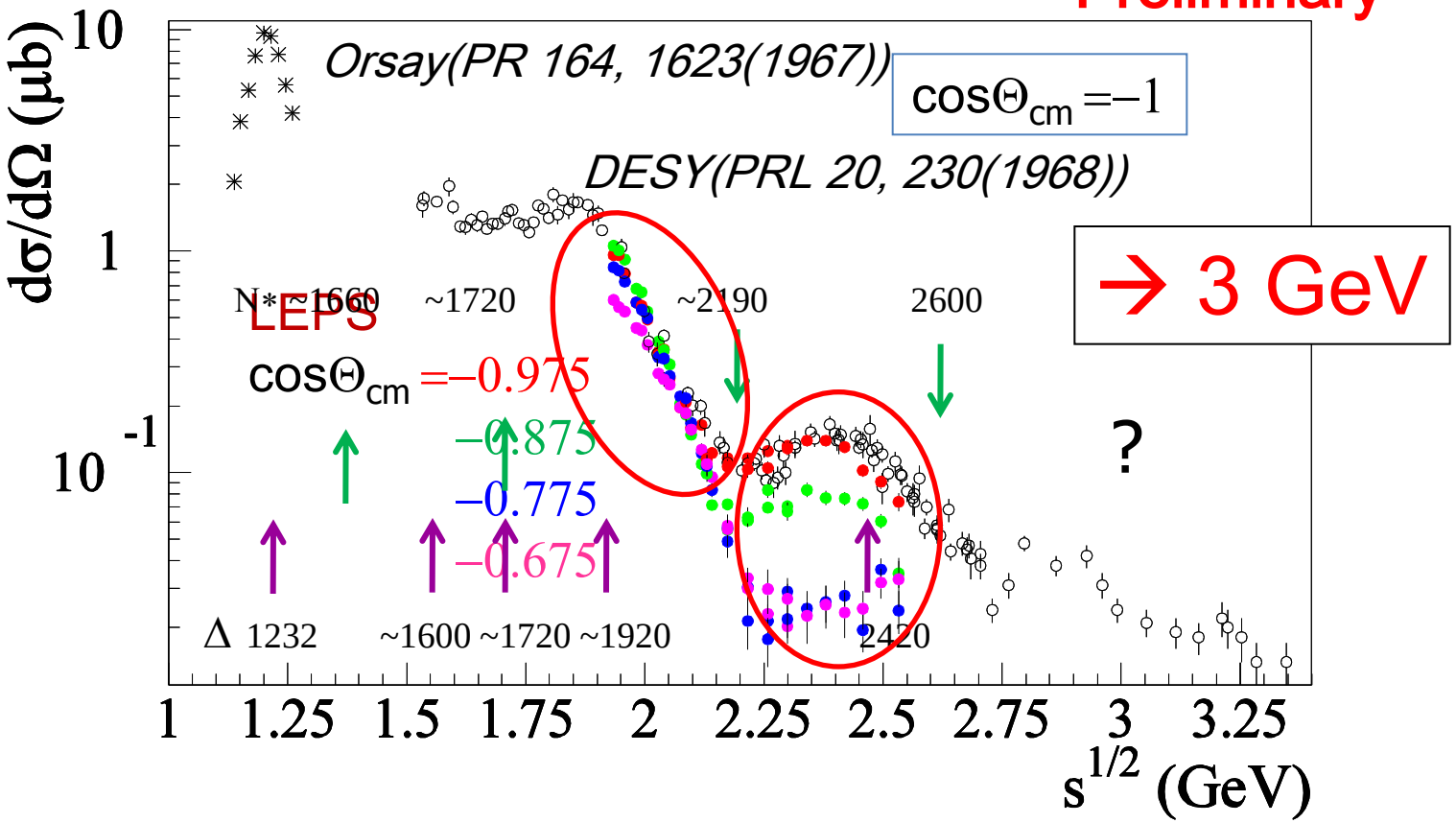
Look at π^0p, ηp, η'p, and ωp, simultaneously

Differential cross sections $d\sigma/d\Omega$ vs. $\sqrt{s}$

π^0

New data

Preliminary



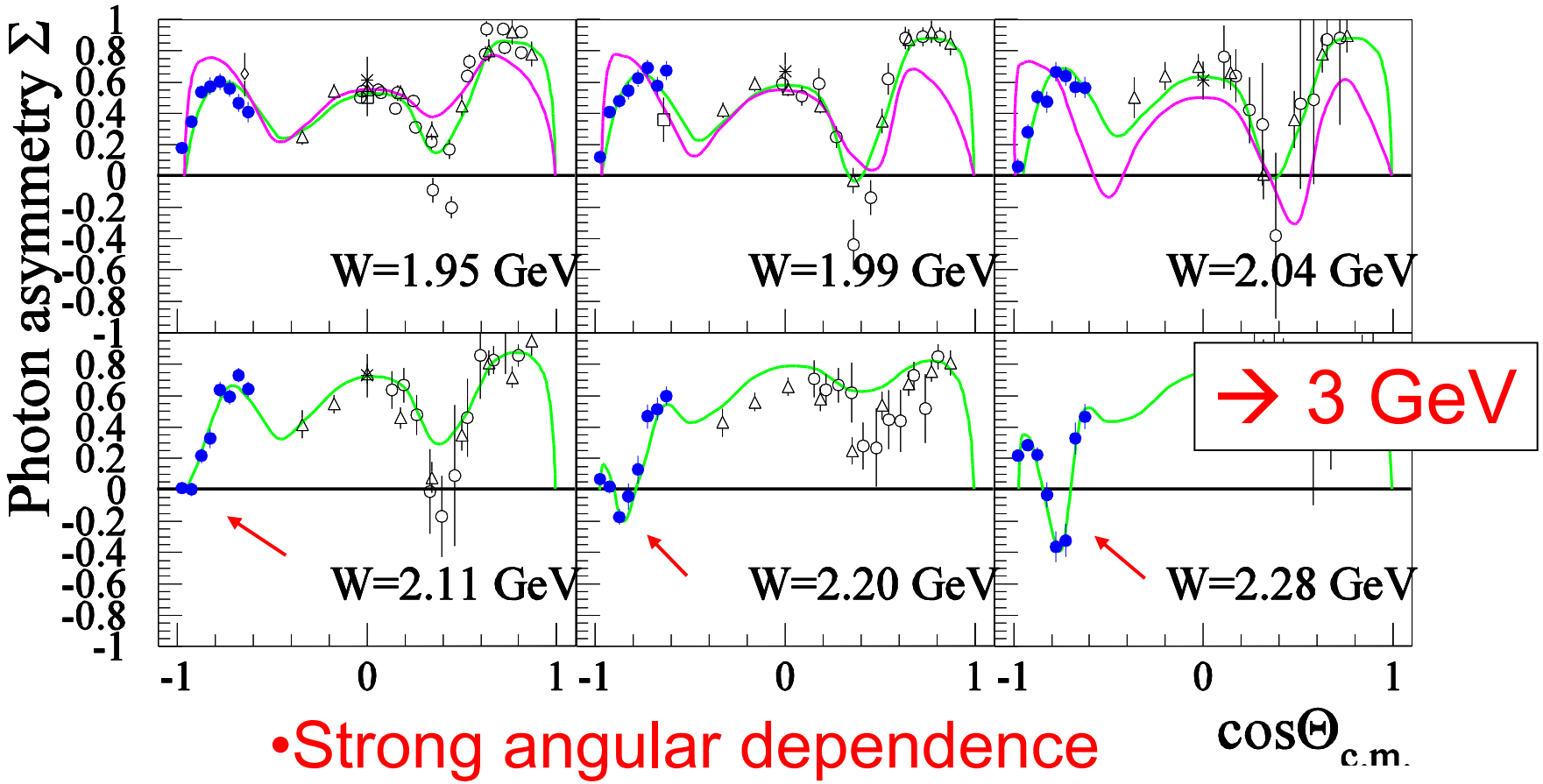
π^0

Photon asymmetries vs. $\cos\Theta_{cm}$

SAID
MAID2007

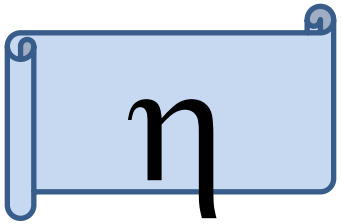
● LEPS data, ○△□ other data 70's

NPB104, 253(76), NPB154, 492(79)



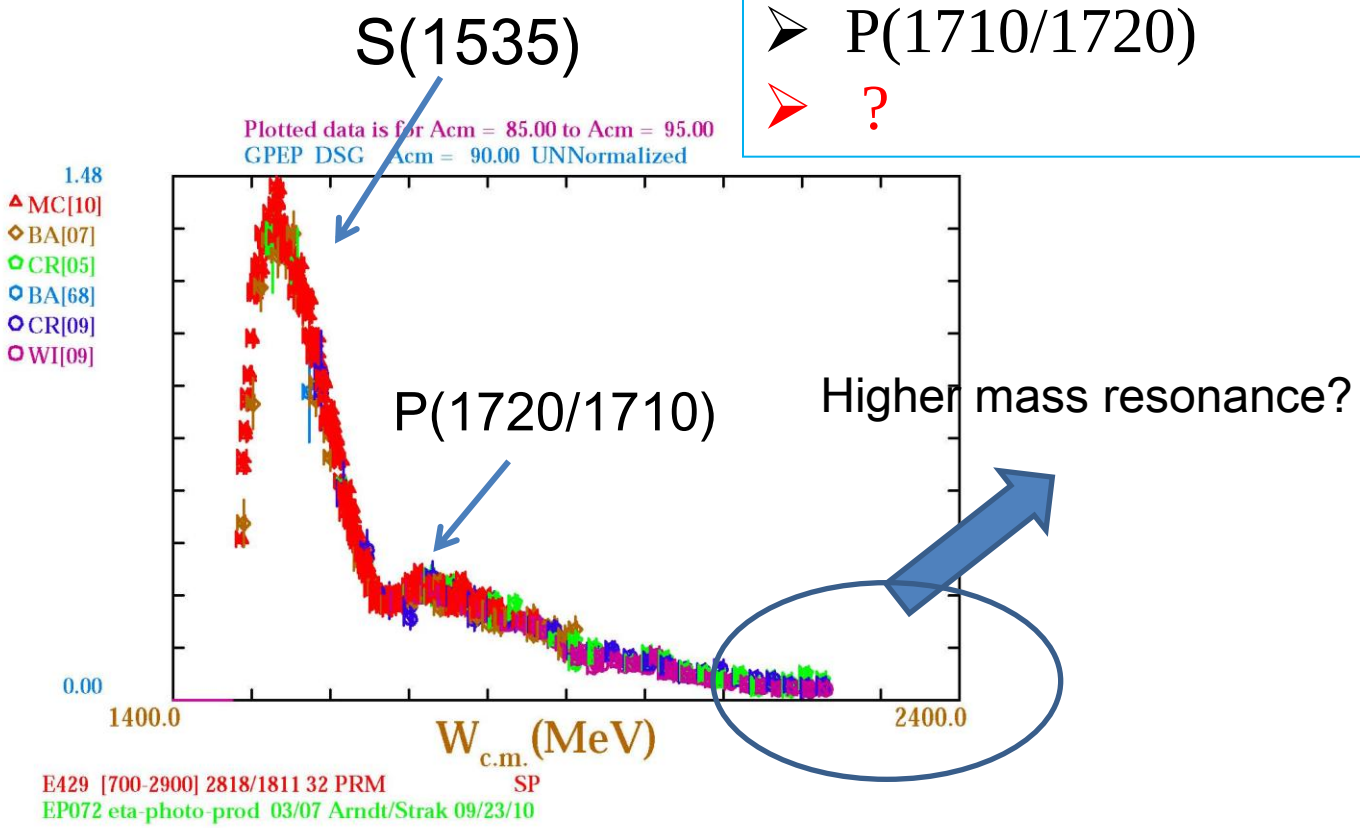
•Strong angular dependence

η photoproduction

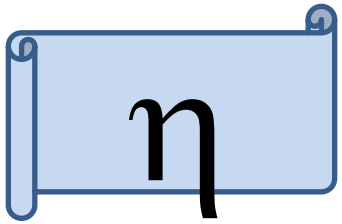


Resonances strongly coupled to ηN.

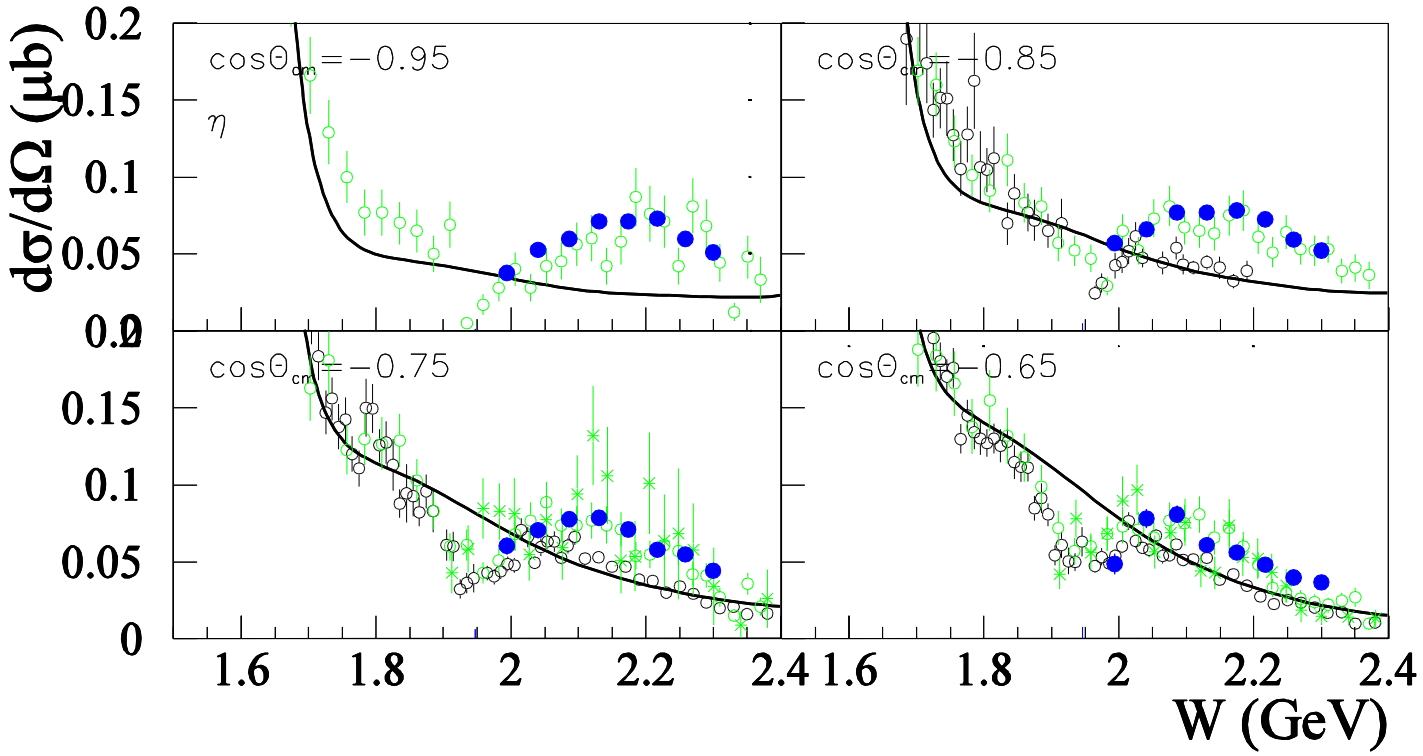
- S(1535) --- contain ss-bar
- P(1710/1720)
- ?



Differential cross sections $d\sigma/d\Omega$ vs. W



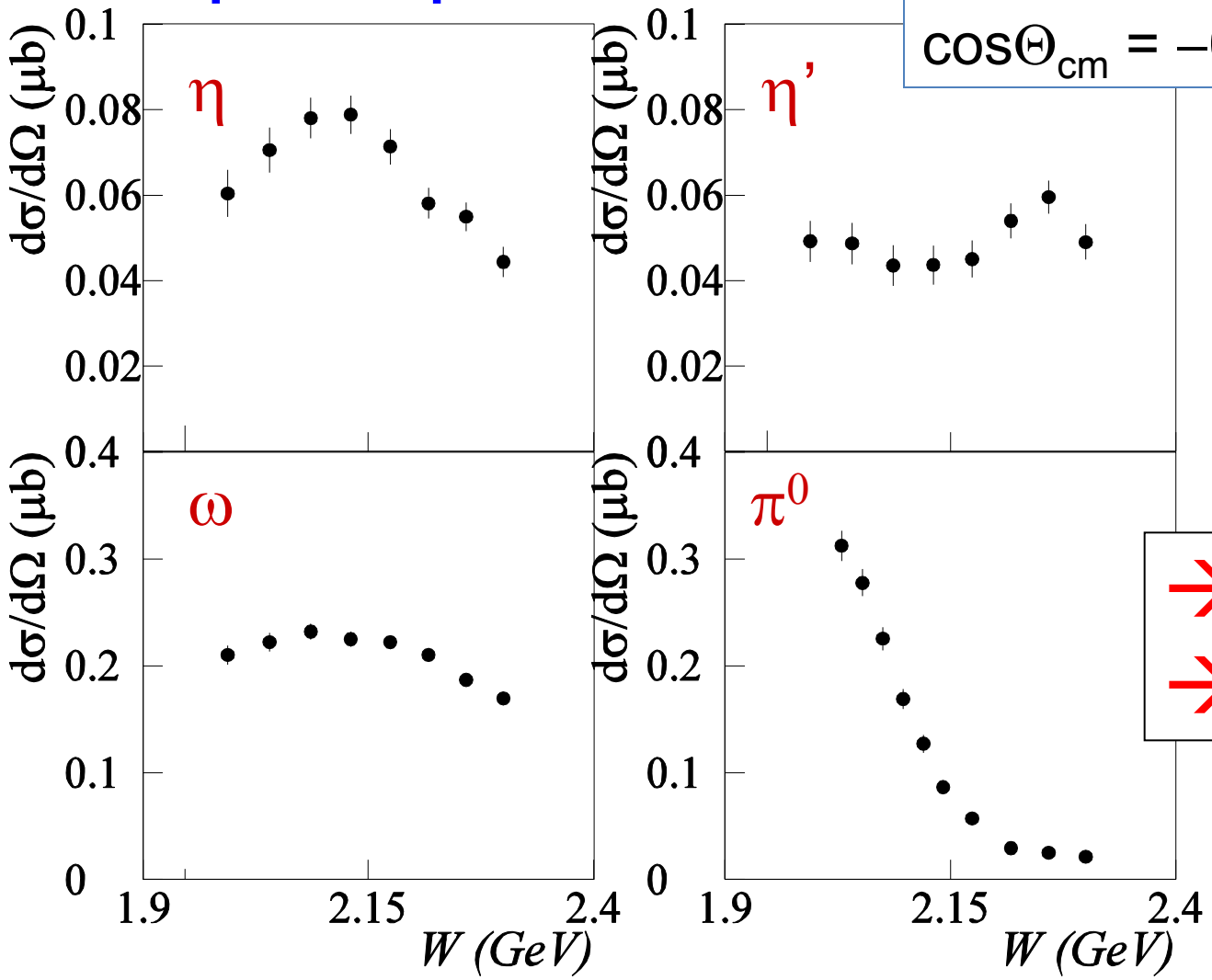
- LEPS data
- Jlab/CLAS data
- Bonn/ELSA data
- SAID -partial-wave analysis



Wide structure is seen above W=2.0 GeV

Comparison of π^0, η, η' and ω photoproductions

$\pi^0\eta$
$\eta'\ \omega$

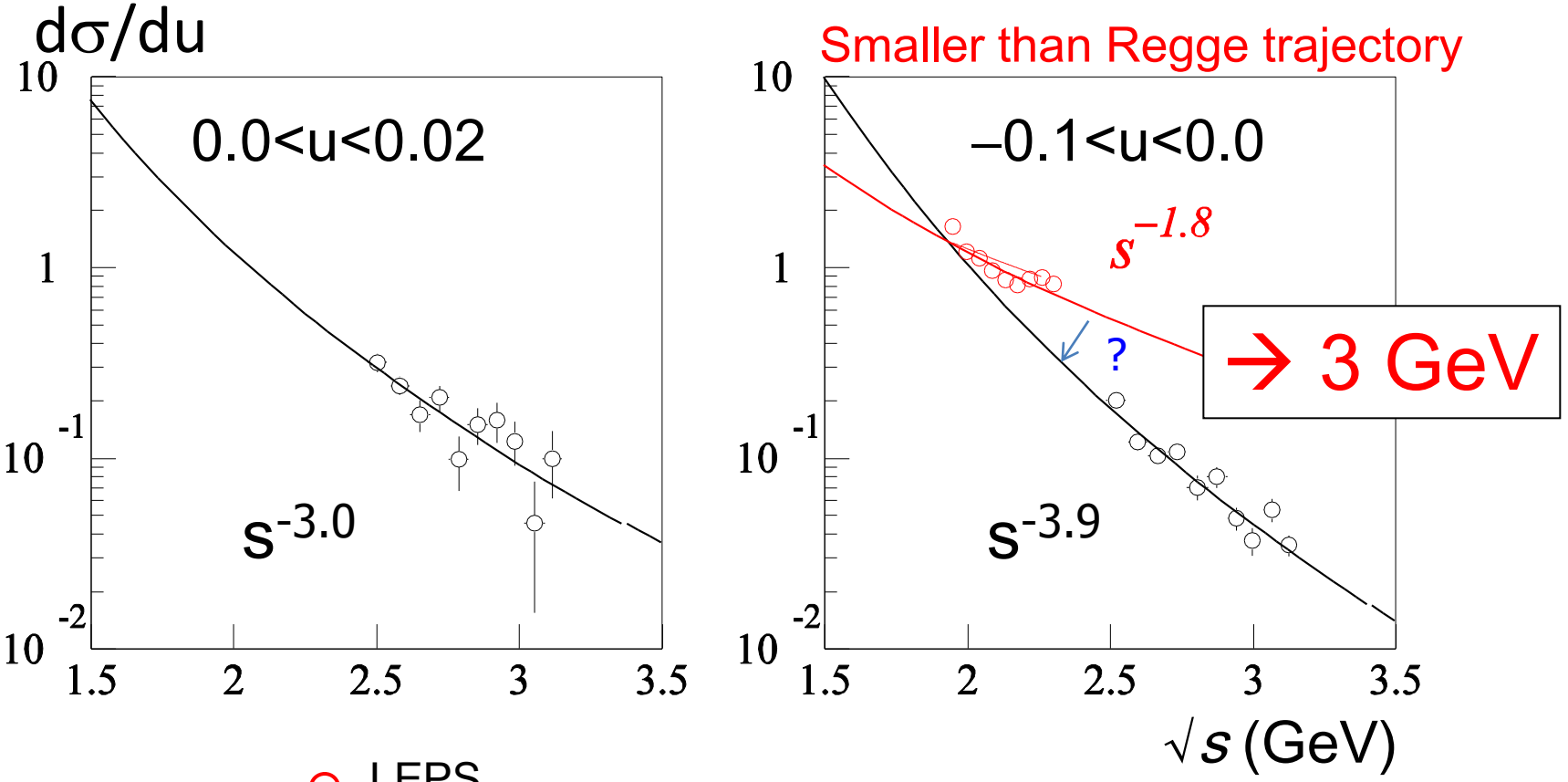


$\cos\Theta_{cm} = -0.8 \sim -0.7$

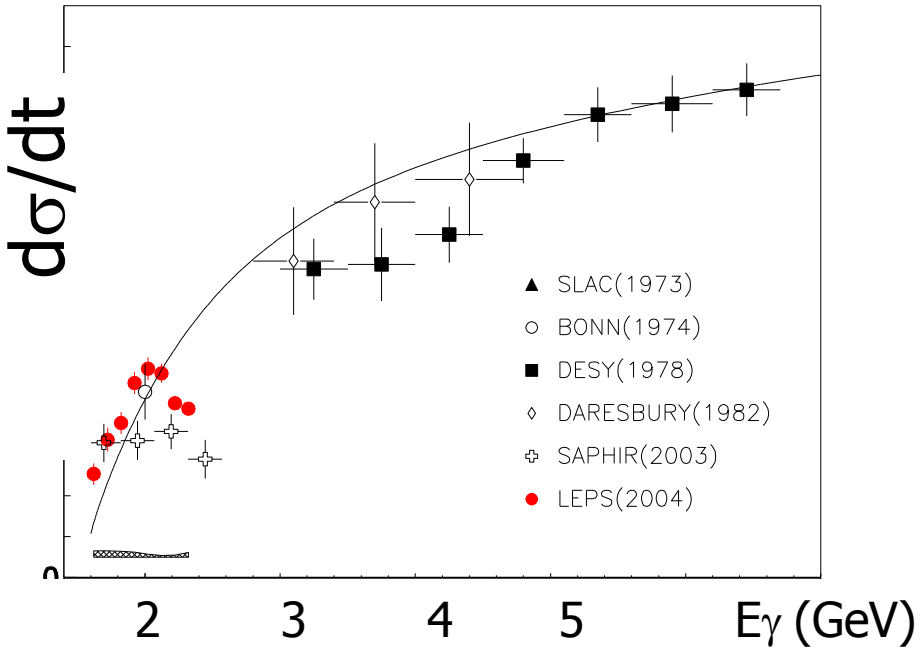
→3 GeV
→ρ, ϕ

ω

dσ/du vs. √s at small |u|



ϕ photoproduction at forward angles



T. Mibe, PRL 95, 182001(2005)

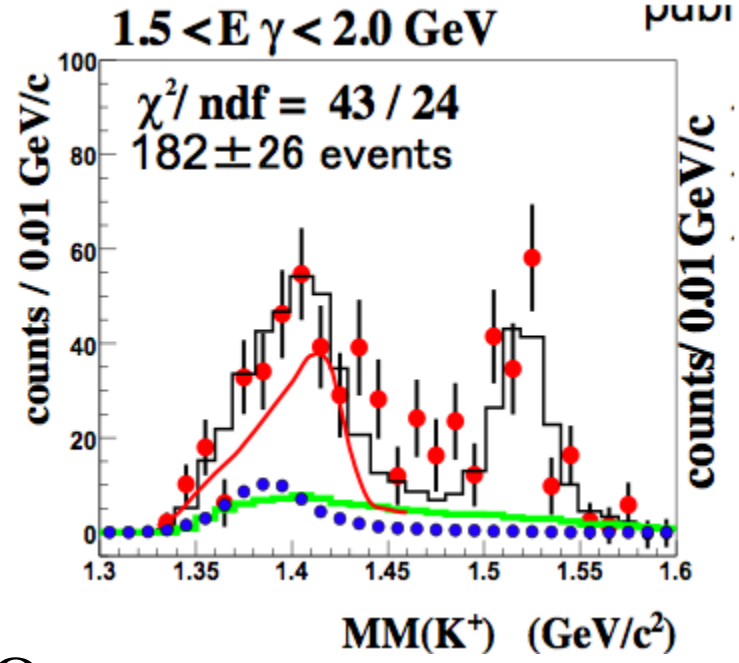
→ 3 GeV

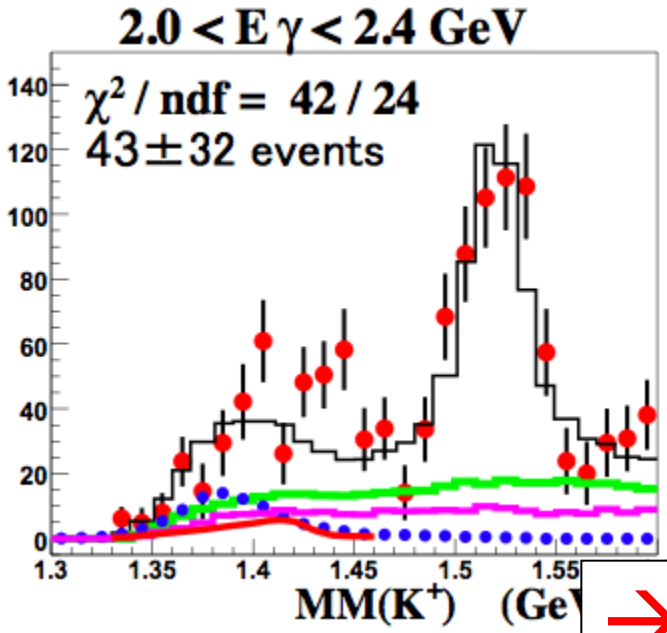
Measurement of γp → $K^+\Lambda(1405)$ and $K^+\Sigma^0(1385)$

M. Niiyama *et al,* Phys.Rev.C78:035202,2008

Decay particles are detected by time-projection chamber

target : H_2 (CH_2 – C)





→LH2

$d\sigma/d\Omega$

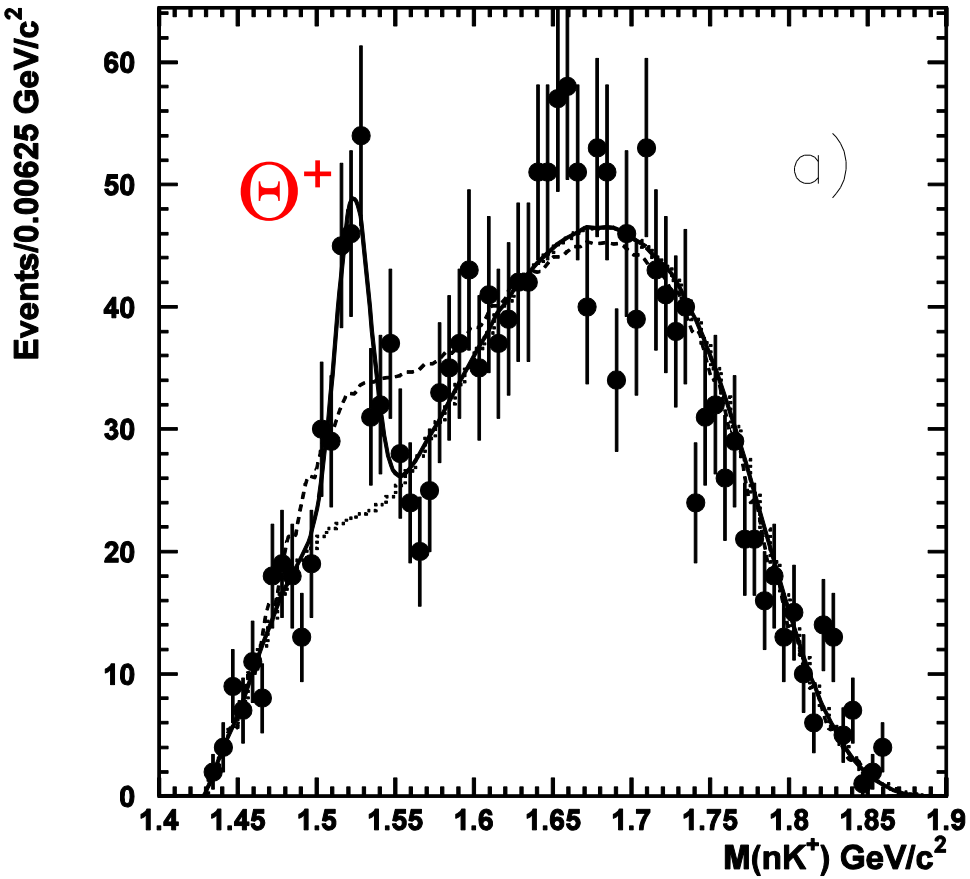
	1.5-2.0GeV	2.0-2.4GeV
Λ(1405)	0.43±0.088	0.072±0.061
Σ^0(1385)	0.80±0.092	0.87 ±0.064

Remarkable decreasing

→different production mechanism or/and internal structure?

Study of Θ^+ ($\gamma d \rightarrow \underline{K^- K^+} np$)

$\gamma n \rightarrow K^- \Theta^+ \rightarrow \underline{K^- K^+} n$



Peak position: 1.527 ± 0.002 GeV/c^2

Signal yeild: 116 ± 21 events

Differential cross-section: 12 ± 2 nb/sr

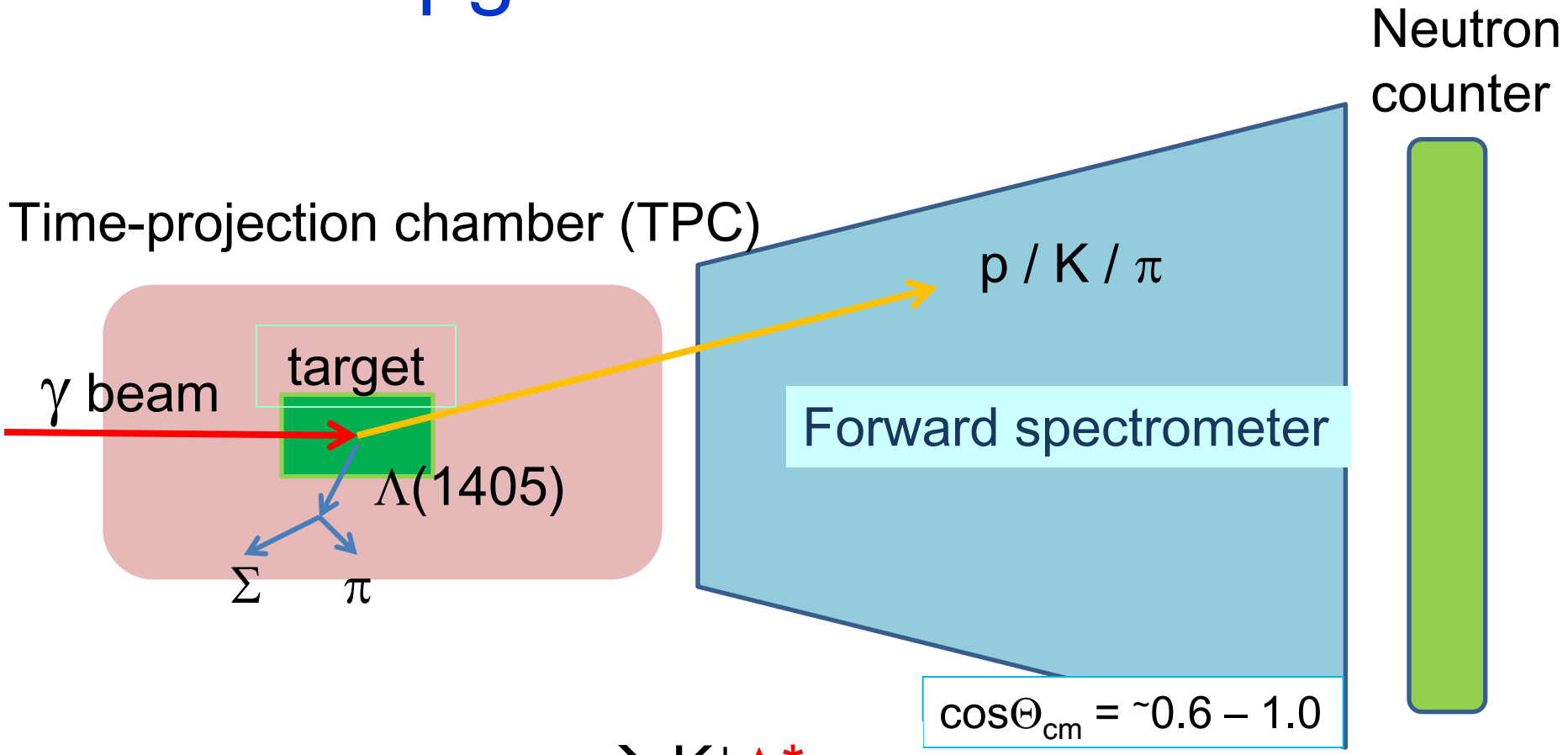
PRC **79**, T.Nakano et al., 025210 (2009)

Higher statistics (3 times) in data taken in 2006-7.
Still under analysis.

Upgrade (new setup) of LEPS

- E_γ^{max} = 2.4 GeV → 3.0 GeV
  - Two laser injection
  - Energy dependence at higher energy
  - with fwd spec. and LH2 and LD2 in 2007 ~
- New Time-projection chamber
  - E_γ dependence of $\Lambda(1405)$, $\Sigma(1385)$
  - $\omega/\rho/\phi$
  - Liquid hydrogen target was used.
  - Total luminosity : 3 times larger than previous work
- Neutron counter
  - new channel with n in 2010~

Upgrade of detectors

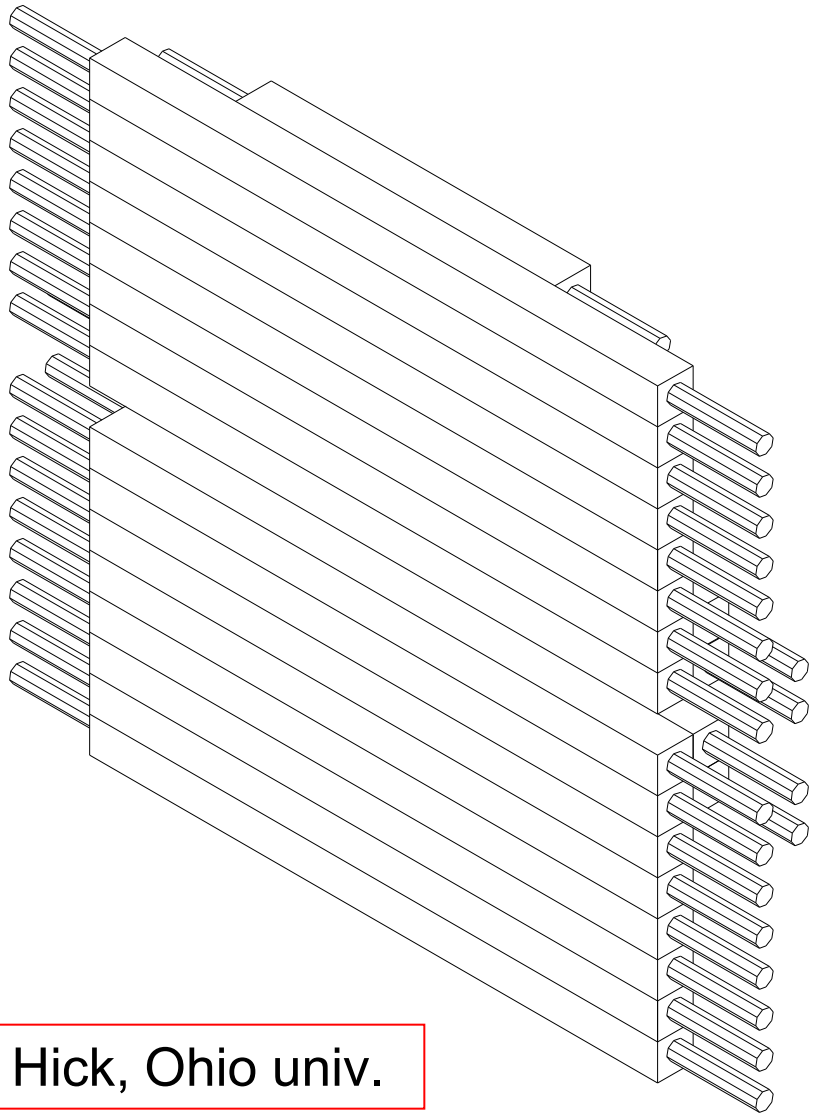


$\gamma p \rightarrow K^{+}\Lambda^{*}$

$\gamma p \rightarrow p\ \omega/\rho/\phi$

Missing mass

Neutron detector



$\gamma d(pn) \rightarrow K^+ \Lambda n$

$\gamma n \rightarrow K^- \Theta^+ \rightarrow K^- K^+ n$

$\gamma p \rightarrow K_s \Theta^+ \rightarrow K_s K^+ n$

$\gamma n \rightarrow \phi n$

$\gamma n \rightarrow K^- \Sigma^+ \rightarrow K^- K^+ n$

$\gamma p \rightarrow K_s \Sigma^+ \rightarrow K_s K^+ n$

Just behind the TOF wall

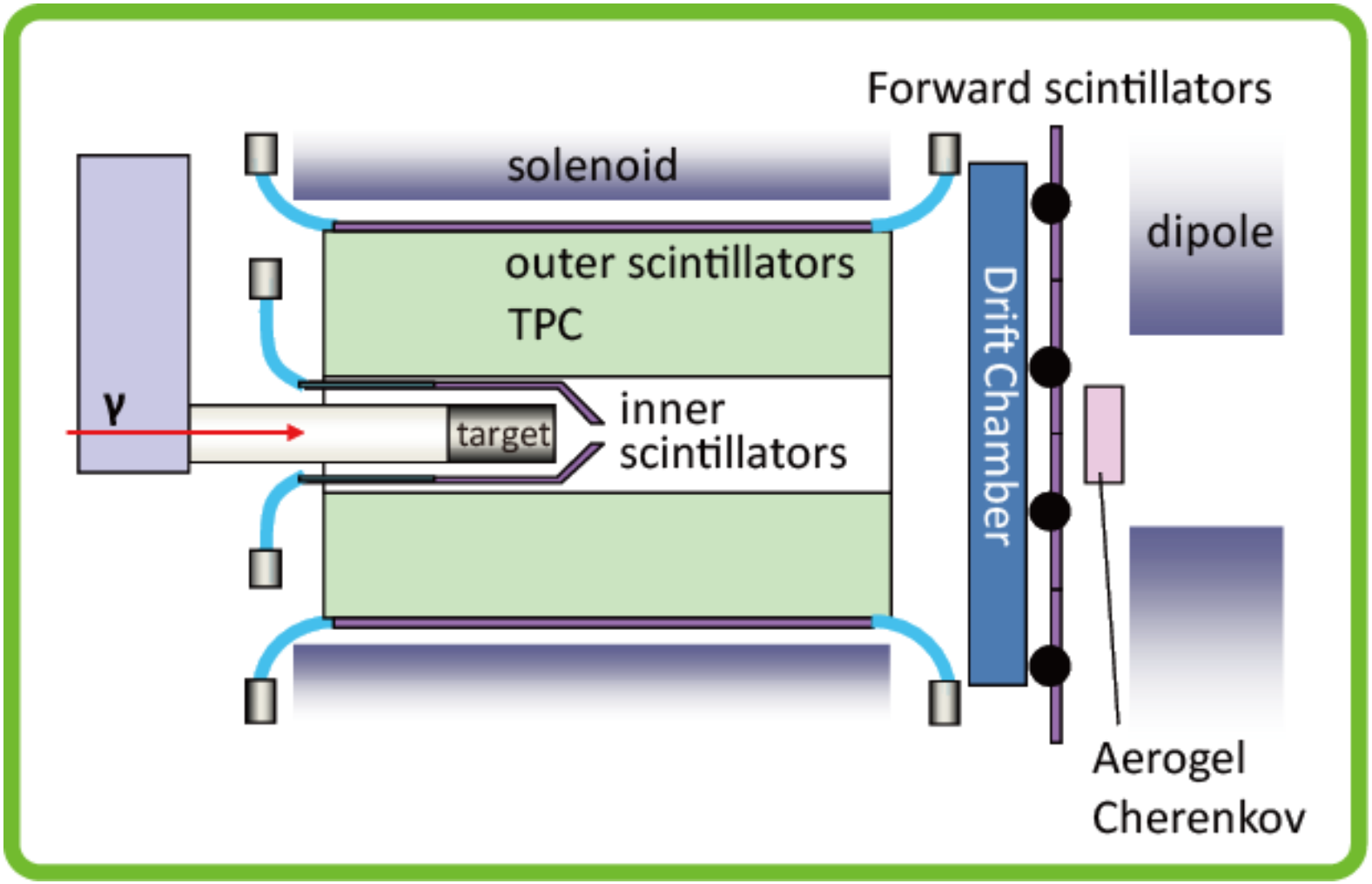
- 1.6 m (y) x 3.8 m (x)
- Cover acceptance of fwd spectrometer

A typical efficiency is 20%.

By K. Hick, Ohio univ.

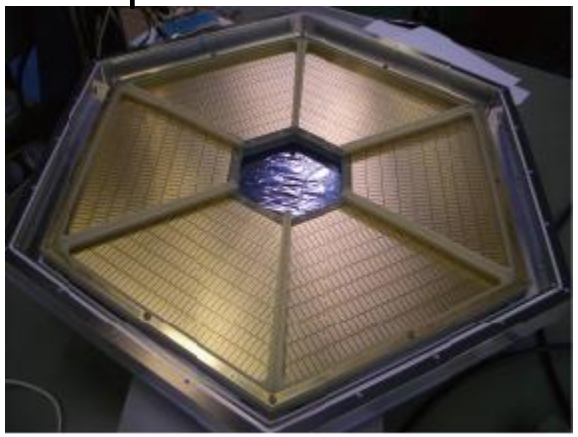
Setup of time projection chamber

with LH2/LD2

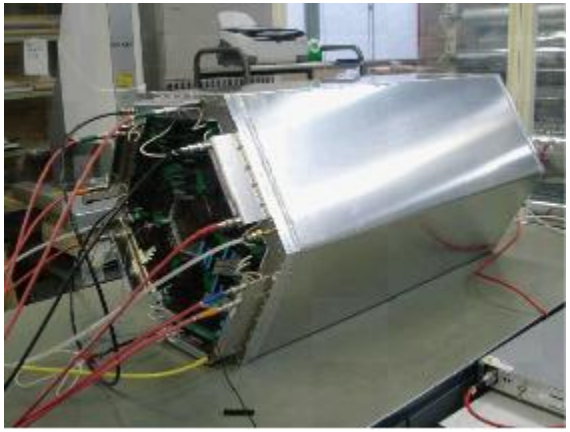


Time projection chamber

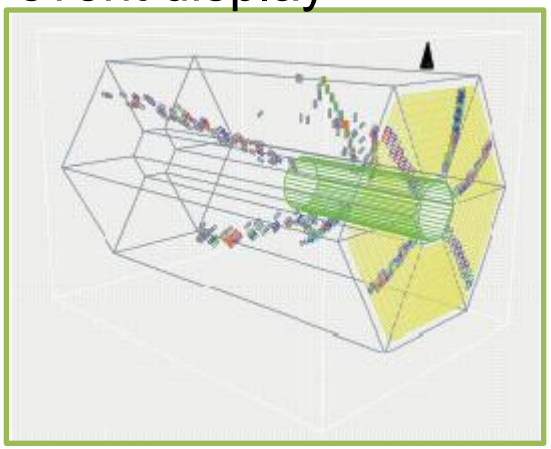
Pad plane



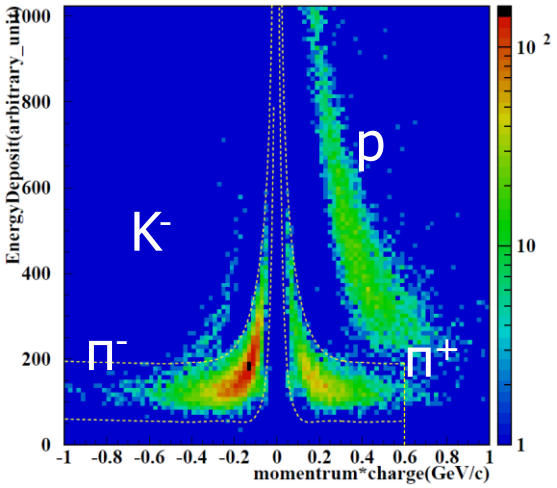
full view



event display



PID with TPC



x-y resolution : 200-300mm
z resolution : ~700mm

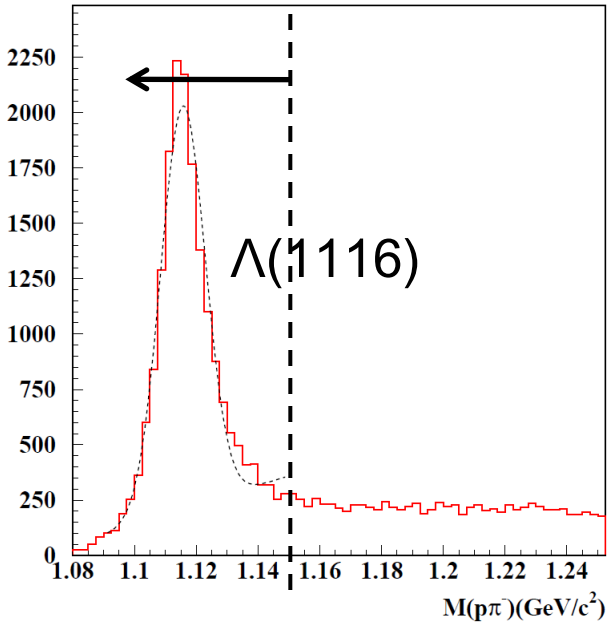
Measurement of
$\gamma p \rightarrow K^+\Lambda(1405)$ and $K^+\Sigma^0(1385)$
$\gamma p \rightarrow \omega p, \rho p, \phi p$ ..

Analysis Spectrum of $\Sigma^0(1385)$

$\gamma\, p \rightarrow K^+\, \Sigma^0(1385) \rightarrow K^+\, \Lambda(1116)\, \pi^0 \rightarrow K^+\, p\pi^-\, \pi^0$

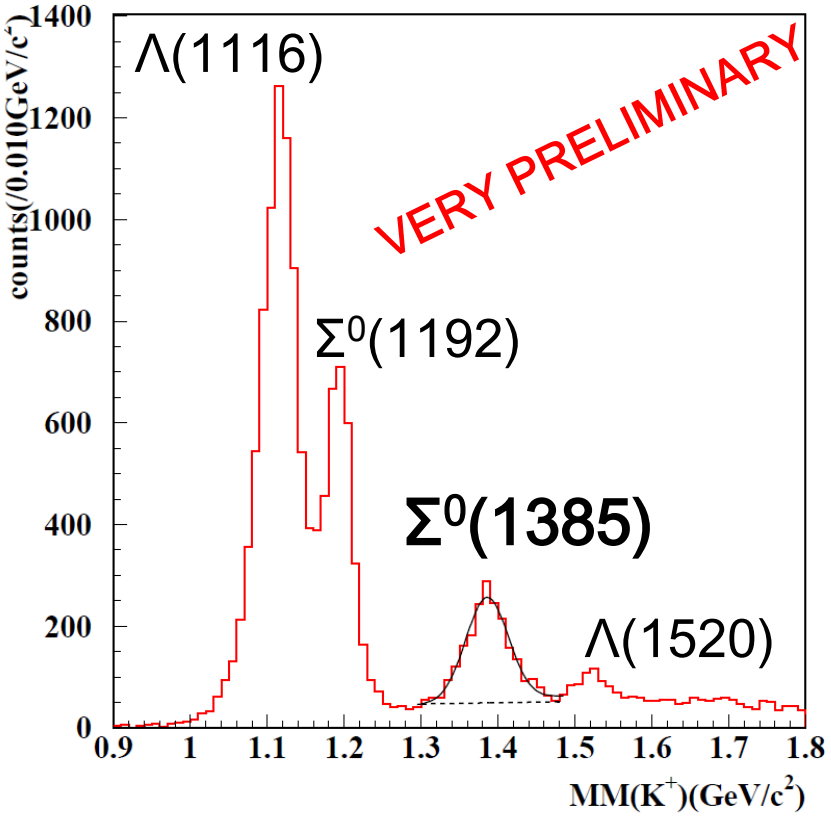
K^+: spectrometer, $p\pi^-$: TPC

M($p\pi^-$) in the TPC



$\Lambda(1116)$ peak :
1.1157 ± 0.0001 GeV/c^2

missing mass spectrum of $\gamma(p,K^+)$ X

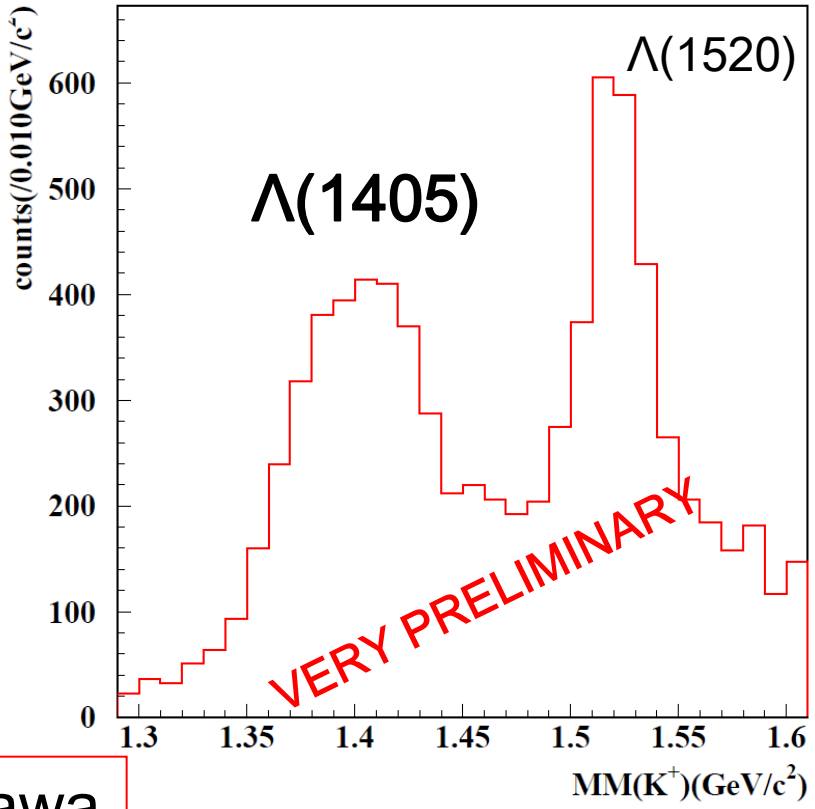


By Y. Nakatsugawa

$\gamma\, p \rightarrow K^+\, \Lambda(1405) \rightarrow K^+\, \Sigma^{\pm}\, \pi^{\mp} \rightarrow \boxed{K^+}\, n\, \boxed{\pi^+\ \pi^-}$

spectrometer TPC

missing mass spectrum of $\gamma(p,K^+)$ X



By Y. Nakatsugawa

Summary

- π^0 / η photoproduction
  strong angular / energy dependence
  → missing resonance?
- $\Lambda(1405)$ / $\Sigma^0(1385)$ / $\Lambda(1520)$ photoproduction
  remarkable energy dependence
- Θ^+ under analysis with 3 times statistics.
  under analysis
- Upgrade of LEPS

  E_γ^{max} = 2.4 GeV → 3.0 GeV with LH2 and LD2 in 2007 ~
  New Time-projection counter with LH2
  - E_γ dependence of $\Lambda(1405)$, $\Sigma(1385)$
  - Liquid hydrogen target was used.
  - Total luminosity : 3 times larger than previous work

  Neutron counter
  new channel with n

Recent publication:

- Measurement of Spin-Density Matrix Elements for ϕ-Meson Photoproduction from Protons and Deuterons Near Threshold.
W.C. Chang *et al.*, Phys.Rev.C82:015205,2010.
- Near-Threshold $\Lambda(1520)$ Production by the $\gamma p \to \Lambda(1520)$ Reaction at Forward K^+ Angles,
H. Kohri, *et al.*, Phys. Rev. Lett. 104, 172001 (2010)
- Measurement of the incoherent $\gamma d \to \phi pn$ photoproduction near threshold,
W.C. Chang, M. Miyabe, T. Nakano, *et al.*, Phys.Lett.B684:6,2010
- Backward-angle η photoproduction from protons at E_γ=1.6-2.4 GeV,
M. Sumihama, *et al.*, Phys. Rev. C 80, 052201(R) (2009)
- Near-threshold photoproduction of $\Lambda(1520)$ from protons and deuterons,
N. Muramatsu, J.Y. Chen, W.C. Chang, *et al.*, Phys.Rev.Lett.103:012001,2009
- Evidence of the Θ^+ in the $\gamma d \to K^+K^-pn$ reaction,
T. Nakano, N. Muramatsu, *et al.*, Phys.Rev.C79:025210,2009
- Cross Sections and Beam Asymmetries for $K^+\Sigma^{*-}$ photoproduction from the deuteron at E_γ = 1.5-GeV - 2.4-GeV,
K. Hicks, D. Keller, H. Kohri, *et al.*, Phys.Rev.Lett.102:012501,2009
- Photoproduction of $\Lambda(1405)$ and $\Sigma^0(1385)$ on the proton at E_γ = 1.5-2.4-GeV,
M. Niiyama, H. Fujimura, *et al.*, Phys.Rev.C78:035202,2008

……

LEPS collaboration

D.S. Ahn, J.K. Ahn, H. Akimune, Y. Asano, W.C. Chang, S. Date, H. Ejiri, H. Fujimura, M. Fujiwara, K. Hicks, K. Horie, T. Hotta, K. Imai, T. Ishikawa, T. Iwata, Y.Kato, H. Kawai, Z.Y. Kim, K. Kino, H. Kohri, N. Kumagai, Y.Maeda, S. Makino, T. Matsumura, N. Matsuoka, T. Mibe, M. Miyabe, Y. Miyachi, M. Morita, N. Muramatsu, T. Nakano, Y. Nakatsugawa, M. Niiyama, M. Nomachi, Y. Ohashi, T. Ooba, H. Ookuma, D. S. Oshuev, C. Rangacharyulu, A. Sakaguchi, T. Sasaki, T. Sawada, P. M. Shagin, Y. Shiino, H. Shimizu, S. Shimizu, Y. Sugaya, M. Sumihama H. Toyokawa, A. Wakai, C.W. Wang, S.C. Wang, K. Yonehara, T. Yorita, M. Yosoi and R.G.T. Zegers

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